MODIS SCIENCE DATA SUPPORT TEAM PRESENTATION*

June 7, 1991

AGENDA

1. Action Items

2. MODIS Airborne Simulator and WILDFIRE

3. MODIS Level-1 Processing

*The MODIS Science Data Support Team (SDST)
was formerly called the MODIS Data Study Team

ACTION ITEMS:

05/03/91 [Team]: Document plans for Level-1A and Level-1B processing, and indicate what information will be included in each product. Include a list of assumptions, brief rationale, scenarios, and trade-offs. A draft version is included in today's presentation. STATUS: Open. Due date 06/07/91

05/03/91 [Lloyd Carpenter]: Prepare a Level-1 processing assumptions, questions and issues list, to be distributed to the Science Team Members and the MCST for comment. The final version was delivered to Al Fleig on 06/05/91. STATUS: Open. Due date 06/07/91.

05/31/91 [Liam Gumley]: Talk with Mike King as soon as he returns about what he wants and what he needs from the SDST as far as MAS processing is concerned. STATUS: Open. Due date 06/21/91

05/31/91 [Liam Gumley]: Talk to Chris Justice at GSFC to find out what the MAS requirements are from the land disciplines. Results will be presented. STATUS: Open. Due date 06/07/91

05/31/91 [Liam Gumley]: Investigate the status of existing WILDFIRE code with regard to the availability, size, complexity, documentation, and the ease with which it could be ported to a different environment. Results will be presented. STATUS: Open. Due date 06/07/91

05/31/91 [Al McKay and Phil Ardanuy]: Examine the effects of MODIS data product granule size on Level-1 processing, reprocessing, archival, distribution, etc. STATUS: Open. Due Data 06/21/91

(1) Talk to Chris Justice for a perspective on the MAS processing requirements of the land disciplines.

I met with Chris Justice at GSFC and he outlined his thoughts on the MAS processing system. His opinion was that he would like to see MAS data in a "Level 1-B" format, that is, calibrated and geolocated to a known accuracy. This Level 1-B MAS data should then be easily ingested into an investigators own processing system. He is also keen to see the development of a quicklook and/or browse facility, where an investigator could look at MAS data, perhaps in uncalibrated/unnavigated form, to determine the coverage of a given flight track and the existence of cloud.

Calibration was stressed as an important issue. MAS data should be delivered with known calibration accuracy. Co-registration within a pixel of the different spectral bands is also critical. It is not clear whether this is an instrument issue or one that can be addressed in the MAS data processing. Navigation accuracy is of lesser, but not insignificant importance. It is expected that ground based data will be used extensively for algorithm validation, therefore requiring MAS pixel ground locations to be well known. Accuracies on the order of half a pixel are desirable. It is important that the aircraft inertial navigation data are available in order to estimate and correct for any geometric distortions in the MAS image data.

He also thought that it would be useful to use the MAS processing system as a prototype for the MODIS processing system. This would allow investigators to get used to the processing system before the launch of MODIS. He is interested in performing MODIS data simulations, where MAS data is modified is some way to look like MODIS data. He was also keen to see some continuity in the development of the MAS processing system over the lifetime of the instrument. He suggested the Team Leader Computing Facility (TLCF) might be used.

It was suggested that Huete and Strahler would be useful people to talk to regarding other land discipline requirements.

(2) Find out how much WILDFIRE unique code exists, and get a description.

I called Chris Moeller at the University of Wisconsin-Madison for information about the current MAMS processing code. The code is run on the IBM mainframe MCIDAS system, and is written in FORTRAN. An estimated 30000 to 40000 lines of MAMS specific code exists at present. Of this total, an estimated 10 percent deals with navigation and calibration. The code contains many calls to "canned" MCIDAS routines, which perform functions like opening files, getting data from specified areas, writing graphics output and so on. Chris thinks that the navigation portion of the software should convert easily to MAS, if the target processing

system is a PC-MCIDAS. Conversion to some other platform would be more complicated. The calibration portion of the code would need modification to handle the different spectral channels on the MAS for calculation of brightness temperatures etc. Noise estimates are not performed as part of the calibration process, but are computed in a separate process. No separate documentation exists for the code, however each module of the code contains explanatory comments about the purpose of the module.

(3) Further information about WETNET

I took a look at the WETNET terminal at the Severe Storms Branch. It consists of the following equipment:

IBM PS/2 Model 70-A21,
80387-25 coprocessor,
6 MB RAM,
120 MB Hard disk,
Zenith VGA monitor,
IBM Mouse,
Telebit Trailblazer modem (whereabouts currently unknown),
CD-ROM drive.

MODIS TRACKING LIST
Assumptions, Questions, and Tracking
compiled by the
MODIS Science Data Support Team
6 June, 1991

This master list of assumptions, tracking items and questions approaches a comprehensive list of all items associated with the design of the MODIS data processing. The intent is to clarify issues and prevent misunderstandings. Items that are assumptions have been included in the current MODIS processing design. They may be modified in future revisions as the design becomes further refined. Tracking items are included as reminders for other phases of the design. Questions for groups other than the MODIS Science Data Support Team are included with time tagged responses as received. This list is a living document that will change as needed.

Each item includes justification and trade-off information. Items that require a response from other groups will include dates for tracking purposes.

LEVEL-1A PROCESSING ASSUMPTIONS

013. MODIS Data. All non-duplicate Level-0 data packets with an Application Process ID that designates MODIS data will be retained in the MODIS Level-1A product.

> Duplicate packet, missing packet, and non-MODIS packet statistics will be included in the data product header and metadata, including quality assurance records.

014. Data Granules. MODIS Level-1A data will be stored as granules with a granule header. Each granule will consist of a whole number of complete scan cubes.

> The output data product will not contain partial scan cubes. The granule pre-allocation scheme utilizes a scan cube as a quantum of data. Problems of duplicate scan cubes which may occur, partially filled, at the beginning and ending of Level-1A granules will be resolved in the Level-1B processing.

015. Data Packet Boundaries. A MODIS instrument data packet will not contain data from more than one scan cube.

> This assumption implies that the scan cube boundaries will fall on instrument packet boundaries. A packet of MODIS data will not be scattered across two or more scan cubes. There is no constraint on the relationship between frame boundaries and instrument packet boundaries.

A question has been directed to the MODIS Characterization Support Team (MCST) containing a request to clarify the subdivision of a scan cube into frames and packets. Note that the specifications for the MODIS-N and -T instruments specify a "band interleaved by line" and "pixel interleaved by band" formats respectively for the two instruments. The pixel interleaved by band format is desirable from a science view point to minimize the effect upon a multi-band algorithm of a missing data packet.

016. Unpacking Data. MODIS data will not be unpacked (byte aligned) at Level-1A.

Leaving the data in a packed form minimizes the size of the data set in the absence of data compression. It also minimizes the time and complexity of Level-1A processing. Unpacking the data at Level-1A may increase the probability of error in the lowest level of permanently archived data.

017. Navigating Data. Earth locations of MODIS pixels will not be determined at Level-1A.

This function is contained in the Level-1B process.

018. Instrument Status Comparison. The MODIS Level-1A processing will not check instrument states contained in the Level-0 header against the Instrument Status Information issued by the ICC.

The ICC command status log will not be available for 48 hours after commanding. This precludes its use in a timely manner. If this checking were possible, some problems could be detected in a more timely manner, at an earlier stage.

019. Quick-Look. Level-1A Quick-Look data will be generated using the same version of software as is used for the standard Level-1A product.

This design constraint assures that the revision level of any quick-look product matches that of the standard product and eliminates the undesirability of separate processing programs for standard, quick-look and reprocessing modes. (See the discussion of the quick-look product in the Scenarios section of this document.)

The Level-1A processor is designed to accept data packets which are not in time order provided that the packet sequence has reasonable time locality.

020. Reversibility. Level-1A processing will be reversible to packets of Level-0 data.

> The Level-1A data product, not the Level-0 data packets, will be permanently archived. Therefore, no non-redundant data will be deleted from the Level-0 packets in producing the Level-1A data product.

021. Reversing Software. If necessary, a separate software package will be provided to reverse Level-1A data to Level-0 data packets.

> The separation of the forward and reversing processes allows one program to be modified or updated without disturbing the integrity of the other. This also decreases the size and complexity of these programs, but adds an additional program to the full validation and configuration management responsibility. Duplicate data packets and non-MODIS packets will not be regenerated.

> The separate programs to perform Level-1A processing, to reverse Level-1A to Level-0, and to compare the original Level-0 packets with the reconstructed Level-0 packets, should optimally be written by independent parties to verify documentation of the data formats and eliminate any errors in the processing.

022. Orbit and Attitude Correction. The process of replacing orbit and attitude information already appended to Level-1A data will be done in a separate utility process.

> The current design of the MODIS processor simply appends the spacecraft platform position and attitude data to the Level-1A data product. Thus a utility program can 'patch' the platform data with newer or more correct values without reprocessing the Level-1A instrument data. The data product must contain the version number of the platform position and attitude data in addition to the processing version number to provide a means of checking for inconsistencies. Products based upon a given Level-1A product that has been updated might need to be reprocessed and would require a backwards pointer to the data source with the appropriate database links.

> Note that the spacecraft data could also be provided to the Level-1B process by an external entity rather than having it appended to the Level-1A product. The possibility of multiple versions of this spacecraft data can lead to a lack of concurrence and the resulting lack of consistent results.

> This information is also expected to be used by other processes in addition to the MODIS processes. It is also asynchronous in time to any instrument scan times and therefore must be interpolated to a process requested time. The position and attitude are contained in data packets with a spacecraft unique Application Process ID and may not be available or tracked in coincidence with the MODIS (or other) data packets by the DADS.

023. Processing Log. The MODIS Processing Log will consist of a time ordered list of all MODIS processing events.

> The Processing Log will receive messages in time order from all MODIS processing programs (Level-1A, Level-1B, Level-2, etc.). This allows an audit trail of MODIS problems and events that can be used as quality assurance inputs to other groups. The task of handling the MODIS Processing Log is performed by an external entity that is common to all MODIS processes.

024. Land/Ocean Flags. Land/Ocean, Cloud, or other derived flags will <u>not</u> be included in the Level-1A data product.

> The scan data is in uncalibrated digital (raw) count form thereby precluding the use of any cloud detection algorithm at Level-1A.

025. Land/Ocean Level-1A Products. The Level-1A product will be supplied without separation into land/ocean or other categories.

> Navigation is not performed in the Level-1A process. Therefore, earth referencing information is not available to allow a land/ocean flag to be generated.

026. Level-1A Browse. There will be no Level-1A browse product.

> Browse data derived from raw instrument counts with no earth referencing would be of very limited use. Browse data requirements will be generated by the MODIS Science Team Members.

027. Data Compression. No data compression will be performed within the MODIS Level-1A processing.

> Data compression is best performed in hardware as a transparent, non delaying step, during the transfer of data to/from storage. Software equivalents to hardware data compression techniques can be provided if necessary.

LEVEL-1B PROCESSING ASSUMPTIONS

028. Granule Pre-Allocation. Storage for MODIS Level-1B output data products is defined before input data in processed.

> Defining the sizes and locations of the output product for each execution of the MODIS process allows the MODIS product to be fully generated without any premature aborting of the process. This also simplifies the accounting and correlation of input versus output data products by the scheduler.

> The pre-allocated areas are filled with invalid data indicators which are used in the quality assurance assessment and reprocessing scenarios.

029. Data Granules. During Level-1B processing, the data contained in each MODIS Level-1A data granule will be subdivided into Level-1B data granules.

> This assumption implies that a Level-1B data granule is a subset of one and only one Level-1A data granule. If more than one Level-1A granule is needed to produce a Level-1B granule, this can be accomplished via reprocessing using the current design philosophy.

030. Metadata Appending. Each processing level updates and appends new metadata without deleting previous processing information.

> The metadata for an input product is updated to reflect further processing information. Maintaining the previous metadata items allows backward tracking of information to the original source for debugging and quality assurance. For example: The CDOS Reed-Solomon error statistics can be maintained with the mapped generated product as an indication of the quality of that product. Earlier metadata will provide information which is useful for the generation of higher level products

031. Coordinate System. Coordinates will be represented in the geodetic latitude-longitude coordinate system on a standard ellipsoid.

> Coordinate transformations from the EOS platform coordinate system to the ground based geodetic latitude-longitude coordinate system will be performed by the MODIS processor using standardized transformation routines. Latitude will be given in the geodetic coordinate system to allow better matching with existing maps.

032. Anchor Points. For each scan, a set of anchor points will be selected for interpolating the ground locations of pixels within the scan.

> See the report "An Analysis of MODIS Anchor Point Accuracies for Earth Location", MODIS Data Study Team, Revised: April 5, 1991 for details of the anchor point method.

The ground locations of the selected pixels are determined solely from the satellite position, attitude, and instrument geometry without the use of ground (in-situ) control points.

033. Anchor Point Parameters. The following parameters will be provided in the Level-1B data set for each anchor point: earth location (geodetic latitude-longitude) of the pixel, satellite slant range, satellite azimuth and zenith angles, and solar azimuth and zenith angles (all with respect to the pixel).

The zenith angles are relative to the normal to the local geodetic surface at the pixel. Other needed parameters such as solar to spacecraft relative azimuth can easily be calculated from the appended parameters. The slant range facilitates the computation of any digital elevation model (DEM) corrections in later processes.

034. Anchor Point Error Statistics. No measure of earth location accuracies based upon anchor points will be included in the Level-1B data product.

An indication of anchor point statistical accuracies can be derived externally in a non time critical environment. The accuracies are not unique to an individual data product. Accuracies are to be derived from platform knowledge parameters initially and verified via off-line methods to be available after the MODIS data has been disseminated.

035. Feature Identification No Feature Identification/Ground Control Points will be used at Level-1B for earth location.

No in-situ data, derived either from ground feature selection or a-priori positioning, will be required to produce the Level-1B data product.

036. Level-1B Elevation Correction. There will be no terrain elevation correction (beyond the reference ellipsoid) to earth location at Level-1B.

Any use of a Digital Elevation Model (DEM) will be performed in follow-on processing upon the determination of a DEM procedure and appropriate model.

037. Platform Position and Attitude Knowledge. MODIS Level-1B processing will use the satellite position and attitude knowledge supplied by the EOS project and appended to the Level-1A data.

This assumption implies that the MODIS process will not be executed before the spacecraft position and attitude are known and that if the spacecraft position or attitude are updated after the MODIS data product has been generated, a MODIS reprocessing may have to be initiated by an outside authority. The current MODIS design appends the satellite position and attitude to the Level-1A data product. This can lead to a lack

of concurrence (more than one version of a data set) with the attendant danger of not having the current, most accurate data.

038. Atmospheric Correction. No atmospheric correction of any kind will be applied to the MODIS level-1B data.

The definition of MODIS Level-1B data is at-satellite radiances, uncorrected for atmospheric effects such as absorptive, scattering, and refractive effects.

039. Land/Ocean Flags. Land/Ocean, Cloud, or other derived flags will not be included in the Level-1B data product.

The current Level-1B design contains no provision for data flags. Generating a land/ocean flag would require a Team Member agreed upon coast line database. A cloud flag would require a definitive cloud detection algorithm or means for a multi-valued flag. These data issues have not been studied for use in the MODIS process at the present time.

040. Land/Ocean Level-1B Products. The Level-1B product will be supplied without separation into land/ocean or other categories.

Level-1B MODIS data products are not categorized by spatial parameters when transferred to the archive although the headers and Metadata contain statistics and indicators for this characterization. Data product splitting is a DADS function.

041. Level-1B Browse. The Level-1B process will not generate browse products.

Any required browse products will be generated by a separate browse process in order to take advantage of future technology advances without compromising the main data product processing. This allows technologies such as those currently in development for high definition television (HDTV), windowed graphical user interface (GUI), laser based video, or similar approaches to be used as they are developed without changing the basic Level-1B product generation function. This also allows for the concept of 'on the fly' or demand browse to be implemented.

042. Required Ancillary Data. All information required for MODIS Level-1B processing will be included in the MODIS Level-1A product.

The data product is defined to include its associated metadata. This assumption says that all data required to process to the Level-1B product (including metadata) will be contained within the Level-0 data product. This means that no in-situ data is required, and that no auxiliary data sets are required (i.e. other instrument motions causing momentum effects, platform thermal deformation data not in the MODIS packets, previous MODIS data products, etc.). See also: Engineering Data.

043. Calibration. Calibration algorithms and parameter values will be provided by the MCST.

> Both algorithms and parameters (coefficients) will be incorporated into the Level-1B software by the SDST. Any change of algorithms or parameters will force a Configuration Management revision update. A full validation will be performed to detect overflow, underflow, error trapping, variable availability, etc.

044. Engineering Data. MODIS Level-1B processing will extract instrument engineering values for calibration from each individual scan cube in the Level-1A data only.

> All of the instrument engineering values needed for calibration will be included in Level-1A. No external data source will be required. All values required to perform a calibration of pixels within a scan cube will be contained within that same scan cube. Previous or future scan cube data will not be required to calibrate the current scan cube. If calibration requires a differing approach, the current design will require modification.

045. Instrument Status Comparison. The MODIS Level-1B processing will not check instrument states against the Instrument Status Information issued by the ICC.

> The ICC log will not be available for examination until 48 hours after items have been posted to the log. This time constraint does not allow the MODIS process to compare telemetered data with commanded states. Problems or anomalies detected in the telemetered data stream will be posted to the MODIS data product log and made available to other functions as necessary.

046. Level-1B Quick-Look. Level-1B Quick-Look data will be generated using the same version of software as is used for the standard Level-1B product.

> (See the description under the Level-1A section for this same item.)

047. Data Compression. No data compression will be performed within the MODIS Level-1B processing.

> (See the description under the Level-1A section for this same item.)

048. Processing Log. The MODIS Processing Log will consist of a time ordered list of all MODIS processing events.

> The Processing Log will receive messages in time order from all MODIS processing programs (Level-1A, Level-1B, Level-2, etc.).

QUESTIONS AND ISSUES:

009. Cloud/No-Cloud. At which processing level will the cloud/no-cloud flag come into the system? Who determines if a cloud flag is desirable? Which algorithm is used to determine the presence of a cloud? Is it derived only from MODIS data or some other instrument that must be spatially co-located with MODIS?

010. Quality Checks. Who will provide a list of quality checks to be applied in the Level-1A and Level-1B processing? This includes product quality assurance (missing data, temporal characteristics, etc) and data quality (coherent noise, saturation, etc).

011. Instrument Location Knowledge. Will the definitive values of the spacecraft ancillary data, including satellite position and attitude knowledge (not accuracies), be supplied by the EOS project before Level-1A processing is initiated?

012. Quick-Look Instrument Location. What will be the source of orbit and attitude data for Quick-Look? This may require an orbit prediction model.

QUESTIONS ADDRESSED TO THE MCST:

001. (06/03/91) Data Packets. Will each MODIS scan cube consist of a number of complete instrument data packets which are numbered sequentially in time order within the scan? Will each instrument data packet be provided with a secondary header that includes the frame sequence counter and the scan sequence counter?

002. (06/03/91) History Files. Will the calibration of MODIS data require the use of information derived from earlier or subsequent MODIS data so as to require the generation and use of "history" files?

003. (06/03/91) MODIS-T Tilting. Is there any circumstance under which the MODIS-T instrument will be changing tilt during a scan? If so, will sufficient information be provided in the telemetered data to allow ground locations to be determined during a tilt?

004. (06/03/91) Data Quality Checks. Will the MCST provide a list of data quality checks to be applied in the Level-1A and Level-1B processing? Will the Team Members provide a list of data quality checks?

005. (06/03/91) Anomaly Detection. Will the MODIS Level-1 processing be required to report data anomalies to the MCST, other than as entries to the MODIS data processing log?

006. (06/03/91) Engineering Data. Will the MODIS Level-1A and/or Level-1B processing be required to check and evaluate selected instrument engineering data?

007. (06/03/91) Cloud/No-Cloud Flag. If a cloud/no-cloud flag is requested, how will this flag be derived, and in which data product level will this flag be placed?

RESOLVED QUESTIONS AND ISSUES:

008. Data Available Check. Will the scheduler check to see that the required data is available before calling the MODIS processor?

The answer is yes. However, the SDST may be required to maintain a table which will indicate which data are available.

SCENARIOS FOR THE MODIS LEVEL-1A AND LEVEL-1B PROCESSING

7 June 1991

1. NORMAL PROCESSING:

Normal MODIS Level-1A and -1B processing will be done as required input data elements are received and as the necessary EOSDIS compute resources become available for MODIS use. In normal operations, processing of a MODIS data granule will begin when a complete set of instrument data packets for the granule has been received and required platform ancillary data for the granule is available.

Level-0 MODIS data (instrument data packets) will be received and stored at the local DADS until Level-1 processing begins. When MODIS processing begins, the EOSDIS scheduler will prefetch the required items from the heirarchical data storage system and initiate MODIS processing as processing hardware becomes available.

The CDOS will usually deliver Level-0 data in blocks of one, or at most, two orbits of data. During CDOS processing, data received at the ground station has been error corrected, if possible, has been error flagged, if correction is not possible, and has been bit order reversed if time reversal of received data is required. CDOS processing has also accounted for all received packets, identified any missing data items, and eliminated any duplicate data packets that may have been created during successive playbacks of the on-board tape recorders.

The MODIS Level-1A product is primarily intended to provide a permanent record of MODIS instrument data; it can be reversed to recover Level-0 data, if required. The Level-1A product receives minimal processing. During Level-1A processing, spacecraft ancillary data may be appended to the instrument data to provide a single, integrated source of all the data required to complete Level-1 processing, successive instrument packets are concatenated to produce the Level-1A data granule, and metadata is generated to facilitate data storage and user retrieval of data. By present plans, data will not be unpacked (byte-aligned) during Level-1A processing.

The primary functions performed during Level-1B processing include the Earth-location of MODIS pixels, the radiometric conversion of sensor outputs to obtain physical radiances at the sensor (sensor calibration), and data-handling and accounting functions required to control data flows and monitor data quality. Level-1B processing will also include quality checks to assure proper MODIS instrument operation. Results of the Level-1B instrument checks will not be routinely provided to instrument controllers or the MCST. Instrument controllers and MCST personnel may access the results obtained from Level-1B instrument checks on a demand basis.

2. QUICK-LOOK PROCESSING:

In most cases, the need for quick-look processing can be anticipated. For example, in planned field experiments, an early look at the MODIS data may be a key element in the decision making process directing the ground portion of the experiment. The investigators will coordinate their quick-look processing requirements with the MODIS Team Leader who will provide final approval and coordinate the effort with CDOS and other elements of the EOSDIS.

A MODIS quick-look processing request will be sent to the EOSDIS specifying which data are to be processed. The EOSDIS will adjust priorities and expedite the flow of the data through the CDOS. The SCA will initiate the MODIS Level-1A quick-look processing soon after the data are available.

Quick-look processing may require time-ordering, redundancy elimination, and quality control measures not normally required for standard MODIS processing. However, quick-look processing will be executed using the same version of software as normal processing, and the Level-1A software will be designed to perform these functions.

Platform ancillary data may not be available in time for quick-look processing. In this case an alternate source, such as a predicted ephemeris, will be specified and made available by the EOSDIS for the required platform position and attitude data.

The Level-1A process will notify the scheduler when quick-look processing is completed. The scheduler will then initiate the MODIS Level-1B quick-look processing, which will be executed using the same version of software as normal Level-1B processing.

3. METADATA GENERATION:

4. BROWSE DATA GENERATION:

Since the MODIS science team members have not indicated a requirement for Level-1A browse, no MODIS Level-1A browse products have been planned.

The MODIS Level-1B browse process will be designed for easy adaptation to future technology developments without affecting the standard Level-1B process. To this end, the MODIS Level-1B browse process will be separate from the normal Level-1B process. After each execution of the Level-1B process, the Level-1B browse process will be initiated to generate the standard Level-1B browse product.

Specifics of the Level-1B browse product will be defined by the MODIS science team. This product might include, for example, a time sequence of "scenes", each of

which is generated by sub-sampling the pixels of a rectangular area on the earth's surface. For each pixel, the recorded signals would be included (at reduced resolution) for a specified subset of the available frequency bands. Users would "call up" these browse scenes at will.

If the EOSDIS supports an extended browse product, then users could, at any time, request that special Level-1B browse scenes be generated from archived Level-1B data. In this mode, for example, the user would specify times, earth locations, and frequency bands to be included in the browse scene. The success of this extended browse capability could reduce the need for archiving standard Level-1B browse products.

5.   PROCESSING PREVIOUSLY MISSING DATA:

6.   REPROCESSING:

A.   **New Version of Software:**

B.   **New Version of Ancillary Data:**